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Add-drop multiplexer with signal amplification ability

BACKGROUND OF THE INVENTION

The present invention is related to an optical coupler using a grating filter in which the grating (periodic perturbation of refractive index) is formed in a core of an optical fiber and a portion adjacent the core thereof.

It is thought that the present invention contributes in the field of optical communications. It is useful technology, when only specific wavelength is taken out or it adds the signal of specific wavelength in wavelength multiplex transmission especially.

An optical conventional penetration type filter is described below.

Since it is generally common for the penetrated typed optical filter to be required in the field of the optical communications, the optical fiber grating filter needed to be used combining optical parts including an optical circulator in order to make a predetermined wavelength zone penetrate. Fig. 8 illustrates a pattern diagram of the optical fiber grating filter. Moreover, Fig. 9 illustrates the general reflective properties of the optical fiber grating filter. The optical fiber grating filter formed in an optical fiber 21 is a filter of a reflection type which has the feature which reflects the light of predetermined wavelength, has the function to make other wavelength penetrate, and is excellent in wavelength selection properties at narrow band, and does not almost have insertion loss. Although a

usual reflective zone is approximately 1nm, if a special process is used, it can also realize the reflective zone is 0.2 mm to 10 mm. Fig. 10 illustrates an example which constituted the optical filter of a penetration type is shown combining an optical fiber grating filter 32 and optical circulator 33 in the course of an optical fiber 31. Although a signal incident from a port 1 is outputted to a port 2 if the optical fiber grating filter 32 is formed on the route to the port 2, only specific wavelength (it is called wavelength λB hereupon) is reflected and outputted from a port 3 after it returns back to the optical circulator 33 side. Supposing it inputs two or more signals by which wavelength multiplex is carried out from the port 1, only the signal corresponding to wavelength λB will be outputted from the port 3 and all the signals corresponding to other wavelength will be outputted from the port 2. That is, the multiplex separation of the signal of specific wavelength λB can be carried out.

Moreover, Fig.11 illustrates the example that constituted the optical filter of a penetration type combining the optical fiber grating filter 42 and optical fiber coupler 43 in the course of an optical fiber 41. In this example, the signal inputted from the port 1 is outputted to the ports 3 and 4 by halves by the optical fiber coupler 43. In the port 3, it is reflected with the optical fiber grating filter 42 and the signal corresponding to wavelength λB reinputs to optical fiber coupler 43, and it is outputted to the ports 1 and 2 by halves again. Therefore, one fourth of the inputted signals will be outputted in the port 2. In this case, Supposing it inputs two or more signals by which wavelength multiplex is

done from the port 1, only the signal corresponding to wavelength λB will be outputted from the port 2, and all the signals corresponding to other wavelength will be outputted from the port 3.

In addition, Fig. 12 illustrates the example that formed a rating filter 52 in extension part of an optical fiber coupler 53 and constituted the optical filter of a penetration type in the course of an optical fiber 51. In this example, although the inputted signal from the port 1 by the optical fiber coupler 53, if the rating filter 52 is formed in an extension portion of the optical fiber coupler 53, and only specific wavelength λB is reflected and is and will be outputted to the port 2. In this case, if two or more signals by which wavelength multiplex is done are inputted, the signal corresponding to the wavelength λB is outputted to the port 2, all signal corresponding to other wavelength is outputted to the port 4 and the multiplex separation of the signal of specific wavelength λB can be done.

The problem in the above-mentioned conventional technology is as follows.

At first, in the method shown in Fig. 10, in case of using the combining the optical fiber grating filter 32 and the optical circulator 33, although the insertion loss is in approximately 2 dB between the port 1 and port 2, it is excelled in properties, the problem is that the optical circulator 33 is expensive. Moreover, in the method shown in Fig. 11 by the combination of the optical fiber grating filter 42 and optical fiber coupler 43, if the optical fiber coupler 43 is compared with the optical circulator 33, although it is a cheap device, as for insertion loss, the minimum is also set to 6dB (namely, 1/4). Furthermore, the whole transmission

signal outputted from the port 3 carries out 3 dB (namely, 1/2) fall.

Furthermore, Fig.12 by the combination of the optical fiber grating filter 52 and optical fiber coupler 53, the signal of specific wavelength λ B that is outputted from the port 2 outputted to the port 1 and 4, the signal of specific wavelength λ B outputted carries out 0.4 dB (namely, 9/10) fall of the minimum.

SUMMARY OF THE INVENTION

In light of the forgoing, it consists of grating built-in type optical coupler and an optical amplifier, and has not only multiplex separation of a signal but the function to add specific wavelength, and the excitation light which became unnecessary can be removed effectively and it is enabled to suppress the influence of a fall of the signal light efficiency to take out. Furthermore, since the device does not use optical parts, such as the above-mentioned optical circulator and is altogether constituted by the optical fiber, the affinity with a transmission way is good and it is an object of the present invention to provide a cheap wavelength multiplex transmission system by low connection loss.

According to the invention, there is provided an add-drop multiplexer with signal amplification ability, comprising optical coupler of a grating built-in type with the two same structures and two optical amplifiers.

Moreover, the optical coupler of the grating built-in type of the present invention including molten-extended portion of fiber coupler formed in fiber

grating, the pitch of grating is uniform structure in the length direction, apodization is carried out, and grating length is 2.0 mm and change in induced refractive index is 0.001. Here, apodization uses a window function for induced refractive index change of grating in the length direction of an optical fiber as shown in Fig.13.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanation view showing a first embodiment of the present invention;

Fig. 2 is a side view of a tapered optical fiber coupler showing the first embodiment of the present invention;

Fig. 3 is a sectional view of an optical fiber coupler melted and extended showing the first embodiment of the present invention;

Fig. 4 is a view in properties showing output power properties of Bragg wavelength to a port 2 of the first embodiment of the present invention;

Fig. 5 is a view in properties showing output power properties of exited light wavelength to a port 3 of the first embodiment of the present invention;

Fig. 6 is a view in properties showing properties in output wavelength (extension rate: 0.1; length of tapered portion: 20.5mm; and band of wavelength: 0.98 m) in the first embodiment of the present invention;

Fig. 7 is a view in properties showing properties in output wavelength (extension rate: 0.1; length of tapered portion: 20.5 mm; and band of wavelength:

1.55 μm) in the first embodiment of the present invention;

Fig. 8 is an explanation view of a conventional optical fiber grating filter;

Fig. 9 is a view in properties showing reflecting properties of a conventional optical fiber grating filter;

Fig. 10 is an explanation view showing an example of an optical filter combined with a conventional optical circulator;

Fig. 11 is an explanation view showing an example of an optical filter combined with a conventional fiber coupler;

Fig. 12 is an explanation view showing an example of an optical filter formed a grating at a melted-and-extended portion of a conventional optical fiber coupler; and

Fig. 13 is an explanation view showing an apodization in an optical fiber grating filter in another embodiment of the present invention.

DETAILE DESCRIPTION

Preferred embodiments of the present invention are described in more detail below referring to the accompanying drawings.

Fig. 1 illustrates the composition figure of the example of a first embodiment of the present invention. This multiplexer comprises an optical coupler 1 of the grating built-in type on an input side; an optical amplifier 2 on an input side connected to one of optical fibers 11 on an input side, allowing signal

light inputting; an optical couple 1A of a grating built-in type on an output side including an other of optical fibers 11 on an input side connected to other of optical fibers 11A on an output side of the optical coupler on the input side and providing without connecting one of the optical fibers 11 on an input side and one of the optical fibers 11 on an output side; an optical amplifier 2A on an output side connecting one of the optical fibers 11 on an output side of the optical couple 1A on the output side, outputting signal light; and an connection optical fiber 13 connects through a switch 14 so as to output Bragg wavelength separated by the optical fiber 11A on the input side of the optical coupler on the input side to other optical fiber on the output side of the optical couple 1 on the output side

In addition, means for inputting another Bragg wavelength maybe provided at the optical fibers 11A on an output side of other optical coupler 1A of grating built-in type on an output side. In Fig.1, the signal light inputted from a left is amplified with the optical amplifier, it is inputted into the port 1 of the optical fiber grating coupler (left). Subsequently, only signal light corresponding to Bragg wavelength of a rating coupler is outputted by the port 2, and the other signal light is outputted to the port 4. Next, the outputted signal light optical is inputted into the port 4 of a rating coupler (right) provided symmetrically as compared to the left optical fiber grating coupler, and is further outputted to a port 1. Moreover, signal light corresponding to Bragg wavelength is combined from the port 2, and is outputted to the port 1. Therefore, all signal light becomes together, is again amplified by the optical amplifier of an output end, and acts to

the main line. Then the excitation light used for each optical amplifier at this time outputs to the port 3 of the optical fiber grating coupler, and decreases.

Fig. 2 illustrates a side view of the optical fiber coupler formed in a shape of a taper form and Fig. 3 illustrates a sectional view of the optical fiber coupler having a molten-extended portion. The numeral 11 shows an optical fiber; the numeral 12 is a filter having optical fiber grating; the mark of C0 shows the width of two optical fibers without molting and extending; the mark of Cmin shows a width of the thinnest portion of optical fiber coupler which is molten-extended; Lc is a length of the taper portion of optical fiber coupler which is molten-extended (the length of the portion is not greater than 0.9 C0 hereupon); and Lg is a length of the grating. Also it sets the ratio of C0 and Cmin to extension ratio τ.

The method of producing the optical coupler of a grating built-in type shown in Fig. 1 is described as follows. At first, molting and extending of the two optical fibers 11 is carried out by the heating molten-extended method, and the optical fiber coupler is produced. Next, the formation position of the grating is determined. In this invention, the grating shall be symmetrically formed to the center of a taper part. Using the double luminous flux holographic interometry or the phase mask method, the formation method of grating irradiates violet lays with a wavelength of about 244 nm from the side, and builds the on-the-strength stripes of irradiation light by interference. Since the induced refractive index of an optical fiber core part changes according to the intensity of violet lays, grating

is formed. In this embodiment, since the target signal wavelength is used as 1.55 μm band, the pitch of interference fringes could be approximately 0.5 μm.

First, it is the optical fiber to which the used optical fiber 11 added Ge (Germanium) to the core, and added germanium and F (Fluorine) to crud in production of optical fiber coupler. The refractive index of the core and crud of the optical fiber 11 are 1.4624 and 1.4580, respectively. Produced optical fiber coupler is a coupler with wavelength dependability, for example, when the signal of wavelength the band of 1.55 micrometers is inputted from the port 1 shown in Fig.1, it is outputted to the port 4. The length Lc of the taper portion of the optical fiber coupler is approximately 20 mm. If the grating has a length of 2 mm, and an extension ratio is 0.1, o.15 and 0. 2, in 15 and 0.2, the optical coupler of the grating built-in type is produced while the length of the taper of optical fiber coupler is changed. At this time, induced refractive index change is set to 0.001. In each situation, the output efficiency of Bragg wavelength to the port 3 is shown in Fig. 4, and the excitation light is shown in Fig. 5 for the output efficiency to the port 2. The Bragg wavelength is set to 1.545 μm and the wavelength of excitation light wavelength is set to 0.98 μm.

When the extension ratio is 0.1 and a taper has a length of 20.5 mm, the output efficiency of Bragg wavelength to the port 2 is 67.6 %, and output efficiency of excitation light wavelength to the port 3 is 99.9 %. At this time, the output properties to the port 3 of 0.98 μm is shown in Fig. 6, the output property to the port 2 of 1.545 μm is shown in Fig. 7.

In result, by changing the form of the taper of coupler, the excitation light for optical amplification removes about 100 %, and it is enabled to combine or divide the signal light corresponding to Bragg wavelength out of the signal light amplified

According to the present invention, as stated above, it consists of optical coupler of the grating built-in type and optical amplifier and has not only multiplex separation of a signal but the function to add specific wavelength. Accordingly, the excitation light that became unnecessary can be removed effectively and it is enabled to suppress the influence of a fall of the signal light efficiency to take out. Furthermore, since the device does not use the optical parts including the above-mentioned optical circulator and is altogether constituted by the optical fiber, the affinity with a transmission way is good and it is an object of the present invention to provide a cheap wavelength multiplex transmission system by low connection loss.